THE SEQUENCE AND DISTRIBUTION OF LUDLOVIAN, LOWER DEVONIAN, AND COUVINIAN CORAL FAUNAS IN THE UNION OF SOVIET SOCIALIST REPUBLICS

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ABSTRACT. The records of coral faunas in the U.S.S.R. are summarized and some suggested synonyms mentioned. The distribution of the faunas is discussed and characteristic faunal elements for the different horizons are given. In particular, first and last occurrences of genera are noted as these may be of stratigraphical value.

THIS review has been facilitated by several recent Russian reviews (Dubatolov 1964, Spasskiy 1964, Kal'o 1965, Nikiforova and Obut 1965, and Ivanovskiy 1965*b*), but is based in the main on the very numerous papers descriptive of the Ludlovian, Lower Devonian, and Couvinian corals of the U.S.S.R.

Russian coral taxonomy has a somewhat different tradition from that of Europe and America, but I have attempted some reconciliation by suggesting changes in published taxonomy. Russian evaluation of the genera of tabulate corals seems to me to be superior to that of western usage and I have in general adopted it herein. I apologize to my Russian colleagues for any misrepresentations of their views; any such are due to my poor knowledge of Russian. I thank them for their generosity in supplying reprints.

LUDLOVIAN, SKALIAN, and TIVERIAN

Ludlovian, when not qualified, is taken in this review to mean the time of development of the faunas in the post-Wenlockian strata of England deposited before the Ludlow Bone Bed. In Horny's view (1962) this corresponds approximately with the Kopanina Beds of Czechoslovakia. Skalian implies the time of development of the faunas of the Skala beds of Podolia which may or may not be equivalent in age to the Ludlow Bone Bed and perhaps to part of the Downtonian, and may correspond approximately with the Pridoli Beds of Czechoslovakia containing graptolite zones *P. ultimus* to *M. angustidens*. Tiverian implies the time of development of the faunas of the Borszczow and Czortkow beds of Podolia, and by indirect correlation is regarded as approximately equivalent to the Lochkovian of Czechoslovakia. The Lochkovian faunas, by the graptolite correlations of Jaeger (1962, 1965) and the range of *Hysterolites hystericus* (Schlotheim) as established by Solle (1963), are taken to be time equivalents of the Gedinnian and much of the Siegenian of Belgium and Germany. For discussions on the equivalence of the base of the Lochkovian to the base of the Gedinnian see also Alberti (1962, 1963), Boucot (1960), Boucot and Pankiwskyj (1962), Hollard (1963, 1965), and Walliser (1962, 1964). The Pragian of Czechoslovakia is considered roughly equivalent to the remaining Upper Siegenian plus Lower Emsian time as is the Zlichovian of Czechoslovakia to Upper Emsian time. Couvinian and Eifelian stages are regarded as

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approximately equivalent, though it is recognized that the Lower Couvinian (Co_1 of Belgium) may have begun slightly earlier than the Lauch Beds of the Eifel. It would appear from the table given by Erben (1962) that the zone of uncertainty may have narrowed to Co_{1a}; Erben suggests that Co_{1a} may be broadly equivalent to the Heisdorf Beds and a part of the underlying Wetteldorf Beds of the Prum Syncline; the Heisdorf Beds he considers topmost Emsian.

It is believed that justification for these working correlations exists as a result of the Prague (Svoboda, Horny, and Chlupac 1960) and Bonn (Erben 1962) symposia on the boundary between the Silurian and Devonian systems and the colloquium on the Lower Devonian and its limits held in Rennes in 1964 ('Colloque', 1965), and of the subsequent literature, including Hollard (1965).

In the U.S.S.R. the common usage of Lower Ludlovian corresponds reasonably with 'Ludlovian' as defined above, but possibly includes Skalian in some sequences; while the Russian 'Upper Ludlovian' has recently (Nikiforova and Obut 1965) been correlated with the Tiverian of Podolia. In some places it may also include the Skalian.

Podolia

Here the Rugosa of the Malinovetski Formation appear to be Ludlovian as Boucot and Pankiwskyj (1962*a*) suggested, rather than Wenlockian as previously accepted (Różkowska 1946). They include *Weissermelia lindstromi* (Smith and Tremberth) which is illustrated elsewhere at present only from the Hemse group of Gotland and the Ludlovian of Tuva (Soshkina, Dobrolyubova, and Kabakovich 1962), but is reported by Bulvanker (1952) also from the Skala of Podolia. The rest of the Rugosa illustrated by Bulvanker (1952) and by Ivanovskiy (1965*a*) are consistent with a Ludlovian age and the fauna bears a general resemblance to that of the *M. leintwardinensis* zone of England. It consists of *Phaulactis*, *Pilophyllum*, *Rhabdocyclus minimus* (Bulvanker), solitary *Tryplasma*, *Aphyllum* (phaceloid *Tryplasma*?), *Cystiphyllum* including '*Microplasma*', *Holmophyllum*, and *Rhizophyllum*. Boucot and Pankiwskyj (1962*b*) listed *Favosites*, *Alveolites*, *Coenites*, *Thecia*, *Heliolites*, *Halysites*, *Aulopora*, and *Syringopora*. *Halysites* is not listed by them from younger formations in Podolia. According to Sokolov (1962*d*) and Sokolov and Tesakov (1963, p. 124) in the upper Malinovetski horizon there is a distinctive new genus of alveolitoid corals without pores, very common in the Kopanina beds of Czechoslovakia and in the 'Lower Ludlow' of Central Asia; they also state that the upper beds of the Malinovetski horizon and the Skalian horizon have predominant *Favosites* with rare *Squameofavosites*, *Subalveolites*, *Taxopora*, and the last Halysitidae, with *Syringopora* and small thamnoporids. Earlier descriptions are in Venyukov (1899) and Semiradski (1906).

The Skalian Rugosa (Bulvanker 1952, Ivanovskiy 1965*a*) are *Dokophyllum*, *Spongophylloides*, ?*Acanthophyllum nikiforovae* (Bulv.), solitary *Tryplasma* (as *Pholidophyllum* and *Stortophyllum*), fasciculate *Tryplasma* (as *Aphyllum*), three species referred by Bulvanker to *Holmophyllum* but which do not appear to me to be congeneric with *H. holmi*, the type species. Bulvanker recorded *Phaulactis cyathophylloides* Ryder and *Weissermelia lindstromi* (Smith and Tremberth) but did not figure them. *A? nikiforovae* would seem to indicate that Devonian solitary ptenophyllids developed from the Silurian *Spongophylloides*, for this species seems related to the species group *S. perfectus* (Wedekind). This rugosan fauna is certainly still closely related to that of the Ludlovian.

Różkowska (1946) described some of the Rugosa of the Tajna beds of Mazurowka which according to Boucot and Pankiwskyj (1962) include both Skala and Borszczów horizons. Her list is *Spongophylloides grayi* (E. & H.), *S. perfectus* (Wdkd.), *Tryplasma loveni* (E. & H.), *Cystiphyllum* (as *Microplasma*), and *Rhizophyllum gotlandicum* (Roemer). Bulvanker (1952) figured *Phaulactis* from the Borszczów horizons.

Skala Tabulata are considered by Klaaman (1965, p. 38) to indicate that the Skala is of the same age as the Estonian 'Lower' Ludlow (Kaarma to Ohesaare stages). He does not list the Skala fauna, but states that in the overlying Borszczów only *Pachyfavosites kozlowskii* Sokolov (1955, pl. 4) occurs in abundance and that in Gotland the Burgsvik, Hamra, and Sundre horizons at the top of the Gotlandian form a zone of *Pachyfavosites*. He thus deduces that the Tiverian (Borszczów and Czortków horizons of Podolia) is equivalent to the Burgsvik, Hamra, and Sundre. Supporting evidence is necessary before his correlations can be regarded as established. According to Sokolov and Tesakov (1963, p. 124) the Skalian and upper Malinovetski horizons have *Favosites* predominant, with rare *Squameofavosites* and *Subalveolites*. Dubatolov (1963, p. 139) says that *Multisolenia* makes a late appearance in the Skalian of Podolia with *Squameofavosites* but he does not figure it.

The Skalian coral faunas are too little known at present for precise definitions. Present records suggest that *Squameofavosites* and *Thamnopora* entered therein (or in the Lower Ludlow? Upper Malinovetski horizon). Whether the Skalian is Gedinnian or pre-Gedinnian is still for discussion.

We lack definitive studies of the Tiverian (Borszczów and Czortków) corals of the type area in Podolia. The *Phaulactis* figured from the Borszczów by Bulvanker (1952) seems correctly referred to that Silurian genus. Sokolov and Tesakov (1963, p. 128) remark that in Podolia the first representatives of *Pachyfavosites* are characteristic for the Tiverian with extremely rare *Pleurodictyum* and a new genus of alveolitoid corals without pores (Sokolov 1962*d*).

Sokolov (1965, in the unpublished Bull. Ludlow Research Group, No. 12, p. 16) records a report by Obut of the discovery of a great number of *Monograptus uniformis* Přibyl in the upper part of the lower half of the Borszczów horizon, giving direct comparison with the lower Lochkovian of Czechoslovakia.

According to Tarlo (1964) the fishes of the Czortków beds are Lower Gedinnian. If this is so, probably the entire Tiverian of the type area is equivalent to only the early part of the Lochkovian. The 'Upper Ludlovian' or 'Tiverian' of the rest of the U.S.S.R. must be separately evaluated for each region for correlation with the Lochkovian and the Western European stages Gedinnian and Siegenian.

Estonia

To the north-west of the Russian platform, in Estonia, the Kaarma, Paadla, Kaugatoma, and Ohesaare horizons forming the zone of *Favosites similis* Sokolov and *F. kogulaensis* Sok. are taken by Klaaman (1965) to correlate with the Lower Ludlovian of England, and with the Klinteberg, Hemse, and Eke groups of Gotland. The characteristic complex of Tabulata in Estonia is *Favosites forbesi* E. & H., *F. effusus* Klaam., *F. pseudoforbesi* Sok., *Thecia swinderniana* (Goldf.), *Laceripora cribrosa* Eichw., *Parastriatopora commutabilis* Klaam., and *Syringopora schmidti*, but *Palaeofavosites*, *Multisolenia*, *Coenites*, and *Romingerella* also occur. Klaaman considers this fauna

to be still represented in the Skala of Podolia, but does not list the species of the latter. The Estonian tabulatan fauna has been described by Sokolov (1952*a*, 1955) and Klaaman (1962*a*, *b*). Halysitidae are not known in the Ludlovian of Estonia.

Unfortunately the Rugosa have not been re-studied. The illustrations of Dybowski (1873) may be doubtfully interpreted as of *Entelophyllum*, *Phaulactis*, *Micula* or *Entelophyllum* cf. *prosperum* Barrande, *Stauria*, *Strombodes*, *Tryplasma*, and *Cystiphyllum*. Ivanovskiy (1965*b*) listed also *Pilophyllum*, *Acervularia*, *Weissermelia*, *Kodonophyllum*, and *Holmophyllum*, but these have not been figured. No younger corals are known in Estonia.

Novaya Zemlya, Vaygach Island, and Pay Khoy

In this miogeosynclinal milieu (Cherkesov *in* Nikiforova and Obut 1965), the Lower Ludlovian of Novaya Zemlya contains *Favosites* and *Heliolites* and that of Pay Khoy has graptolites. That of Vaygach Island has *Spongophylloides perfectus* Wdkd. and *Pholidophyllum vermiculare* Wdkd. (Strel'nikov 1965*a*, *b*). The overlying Grebeni and Vaygach horizons are together correlated with the Tiverian but Chekhovich (1965) suggests that the Grebeni horizon, widespread also in the Subpolar and Polar Urals, correlates with the Burgsvik–Hamra–Sundre succession of Gotland, and that only the Vaygach horizon of the Sub-polar Urals would correlate with the Tiverian. The Grebeni horizon of Novaya Zemlya contains *Parastriatopora* and *Favosites*, while on Vaygach it contains *Microplasma*, *Favosites*, *Squameofavosites*, and *Syringopora*. The overlying Vaygach horizon on Vaygach contains *Favosites*. The corals of this region have been described by Lindström (1882), Tchernyshev and Yakovlev (1898), Cherkesov (1932), and Chernyshev (1937*a*, 1938*a*, *b*).

Urals

Chernova Uplift. In the Chernova structure that reaches the coast at Sin-kin Nos (Barskaya 1965) the late Silurian to Tiverian has four coral faunal complexes; the earliest of these is characterized by *Parastriatopora* and the second and third by *Thecia* and *Laceripora*, though *Thecostegites* enters in the third, in what may be its earliest appearance anywhere. The fourth has *Squameofavosites*, *Favosites*, *Riphaeolites*, *Thecostegites*, and *Syringopora*. The fourth complex may be Lochkovian; perhaps the third is Skalian; the others seem equivalent to the Ludlovian of Estonia. Strel'nikov (1964) described *Stereoxylodes argutus* from the 'Upper Ludlovian'.

Polar and Sub-polar Urals. In the Sub-polar Urals that lie subparallel to and a little west of the Polar Urals, Chekhovich (1965) recognized (in the Rivers B. Sunya and Kzhim) a zone of *Laceripora cribrosa* and *Parastriatopora arctica* (with *Favosites* and *Coenites*) as approximately equivalent to the early Ludlovian Kaarma and Paadla beds of Estonia. From this zone in the Durnayus suite Strel'nikov (1965*b*) reported that the Rugosa are dominated by *Spongophylloides*, *Zelophyllum*, *Pholidophyllum* (= solitary *Tryplasma*), *Stortophyllum*, and *Holmophyllum*; very rare are *Micula* and *Tenuiphyllum*; some *Tabularia* and *Dentilasma* continue from the Wenlockian and *Stereoxylodes* occurs. Illustrations are not yet available.

Above this, in the lower part of the Into-Parm suite is a zone of *Favosites pseudoforbesi ohesaarensis* and *Howellella pseudogibbosa*, which Chekhovich (1965) equated with the Grebeni horizon of Vaygach Island. *Favosites*, *Parastriatopora*, *Striatopora*?,

Table I. Main stratigraphic or biostratigraphic units mentioned in the text.

Country or Region	Suggested approximately equivalent to:-				
	Ludlovian	? Ludlow Bone Bed	Gedinnian, L & M. Siegenian	U. Siegenian and Emsian	Couvinian
Czechoslovakia	Kopanina	Pridoli	Lochkovian	Pragian & Zlichovian	Eifelian
Podolia	Malinovetski	Skala	1 Borszczow) 2 Czortkow) = Tiverian		
Estonia	1 Kaarma 2 Paadla 3 Kaugatoma 4 Ohesaare				
Novaya Zemlya	"Lower Ludlovian" Grebcni		Vaygach	Morzhov Inlet	Eifelian
Chernova Uplift	Faun. Comp. 1 & 2	F.c. 3	F.c. 4		
Polar and Sub-polar Urals	1 Durnayus 2 L. Into-Parm		U. Into-Parm		Western Slopes 1 Takatin 2 Vanyushkin 3 Vyazov 4 Calceola 5 Biya Eastern Slopes 1 "Eifelian" 2 Beds with Conchidiella bashkirica
Urals	see Nikiforova & Obut (1965) "Lower Ludlovian"		"Upper Ludlovian"	see Spasskiy (1959)	
Taimyr	"Lower Ludlovian"		"Upper Ludlovian"	Lower Devonian	Eifelian
Armenia					Eifelian
Tien-Shan	Dal'yan = Mustavass and Karasuy		1 Isfarin 2 Kunzhak	Akkul Dzhidalin Manak and "Coblenzian"	Katran and Eifelian
Kazakhstan	Akkan f.c.		1 Aynasuy f.c. 2 Burnak f.c. "Upper Ludlovian"	Bogimbay f.c. 1 "Gedinnian" 2 "Coblenzian"	Eifelian
Altai-Sayan	Potapov = Chagyr	Sukhaya	"Upper Ludlovian" Tom-chumysh = Tomskozavod = Lochtev	1 Krekov 2 Malobachat "Lower Devonian"	1 Salairkin 2 Shandin 3 Mamontov Losishin, Tashtyp, Kryukov, Sokolin, Rakitin, & Ust'-Kamen
Amur Geosyncline				1 Bolshenever 2 Imachin Il'dikan and Blagodat	
Verkhoyan - Chukotsk Geos.			Nelyudum	"Lower Devonian"	Eifelian

Numerical sequence gives ascending stratigraphic position in the stage. F.c. = faunal complex.

and *Syringopora* occur in the lower part of the zone which he correlated with the Ohesaare and Kaugatoma beds of the Estonian Ludlovian. In the upper part of the zone the above four genera are joined by the first *Squameofavosites* and *Thecostegites*; possibly this upper part may correlate with the Skalian of Podolia. The rugosan *Scyphophyllum* Strel'nikov (1964) occurs in this zone.

In the upper part of the Into-Parm suite of the Sub-polar and Polar Urals which Chekhovich (1965) correlated with the Vaygach horizon of Vaygach, and with the Tiverian of Podolia, Tabulata are rare but a zone of *Favosites socialis uralicus* and *Hebertella hebe* is recognized; Strel'nikov (1965*b*) reported the occurrence herein of *Orthopaterophyllum* (= *Palaeocyathus* Foerste from the highest Silurian of Yass, N.S.W.), a disphyllid [?] '*Diplophyllum*', *Spongophylloides*, and the spinose *Thecaspinellum* (a cystiphyllid with scaly? epitheca and very simple tabulae), *Pholidophyllum*, *Stortophyllum*, *Cystiphyllum* (including *Microplasma*), *Diplochone*, and *Hedstromophyllum*. Chekhovich (1965, Table) listed *Monograptus formosus* from beds on the R. Limba considered equivalent to the base of the upper Into-Parm suite.

Northern, Central, and Southern Urals. Sytova (1952) described *Kyphophyllum elkinense* and *Entelophyllum uralicum* from the top of the Wenlockian or base of the Ludlovian of the eastern slopes of the Northern Urals. Soshkina (1937) described fasciculate *Tryplasma* and cerioid ?*Tryplasma* (as *Zelophyllum*) from 'Lower Ludlovian' strata of the miogeosynclinal zones of the western slopes; and from the eastern slopes *Entelophyllum* (as *Tenuiphyllum flexuosum* Soshk. and *Xylodes uralicus* Soshk.), solitary *Kodonophyllum*, *Stortophyllum*, fasciculate *Tryplasma* (as *Zelophyllum*), and *Rhizophyllum*. This list may well indicate a Ludlovian age. From the 'Middle Ludlow' of the western slopes cerioid '*Acervularia*' [? = *Zelolasma*], '*Pseudomphyma elongata* Wedekind', solitary *Tryplasma*, and *Stortophyllum* were described from scattered outcrops; the age is doubtful; it may be Devonian. '*Acervularia luxurians* var. *breviseptata* Weiss.' of Soshkina (1937, pl. 17) seems almost identical with *Zelolasma gemmiforme* (Etheridge) from the late Emsian or early Couvinian of eastern Australia. See Pedder (1964) for figures. From the 'Upper Ludlow' (Tiverian?) of the western slopes, possibly a new genus of solitary ptenophyllids was figured as *Omphyma*; and from the eastern slopes *Neomphyma originata* Soshkina and '*Neocystiphyllum*' [? = *Acanthophyllum*] *keyserlingi* (Dybowski). Nikolaeva (1949) described *Thecaspinellum* from the upper Silurian (Ludlovian *sensu lato*) of the Urals (R. Taltiya). I have found no recent discussion of the stratigraphy of these coralline beds, but I have deleted from Soshkina's lists those species whose holotypes were stated by Spasskiy (1960*a*) to be from $D_2$1 Eifelian and not from the Silurian, and other species listed as occurring only with these holotypes.

Taimyr

In the 'Lower Ludlow' of central Taimyr, *Favosites* and *Syringopora* occur (Zhizhina *in* Nikiforova and Obut 1965) and *Squameofavosites* was described by Barskaya (1962) from undifferentiated Ludlovian. Sokolov (1962*d*) reported that the 'Upper Ludlow' (Tiverian) of the Urals and adjoining islands of the Arctic and the Pechora Basin is characterized by very numerous *Squameofavosites*, *Pachyfavosites*, *Favosites* (peculiar small forms of the type of *F. socialis*), and *Syringopora*; and the first *Tetraporinus* appears.

Central Asia

Tien Shan. In this geosynclinal region in the Soviet Republics of south-east Uzbek, Tadzhik (including Pamir and Darwas), and Kirghiz, Ludlovian and Tiverian coral faunas occur in the Turkestan, Zeravshan, Gissar, Alai, Fergana, and Kirghiz ranges (Nikiforova and Obut 1965; Rukhin 1937, 1938*a*; Orlov 1930; Obut 1939; Chekhovich 1955*a*, *b*, *c*; 1956, 1961, 1964; Chekhovich *et al.* 1960; Dubatolov and Chekhovich 1964; Leleshus 1964*a*, 1965).

The Dal'yan horizon and the Mustavass (Yassu-Atbashin belt), Karasuy (Aksan Belt) suites correlated with it are considered Ludlovian, having *Conchidium knightii* and *Favosites*, *Squameofavosites tchernychevi* Chekhovich, *Daljanolites* Leleshus, *Heliolites*, *Helioplasmolites* Chekhovich (1955*c*, 1956), *Propora*, *Halysites*, and *Syringopora*. This is possibly the earliest occurrence of *Squameofavosites*. *Daljanolites* is of creeping habit, with cylindrical branches having corallites with walls thickened so that no tabulae are observed.

The Isfarin horizon with *Pholidophyllum* limestones is considered Lower Tiverian. The only rugosan I have found described is *Chavsakia* Labrusevich (1959), a large solitary cystiphylloid with scaly epitheca and coarse dissepiments and tabulae, recalling *Thecaspinellum* from the upper part of the Into-Parm suite of the Polar and Sub-polar Urals; but Sokolov (*in* Nikiforova and Obut 1965) determined *Columnaria*, *Thecaspinellum*, *Cystiphyllum*, and *Holmophyllum*. These occur with *Favosites*, *Squameofavosites*, *Pachyfavosites*, *Cladopora*, *Heliolites*, *Propora*, *Syringopora*, and *Thecostegites*. In the Dzhangdzhei Belt *Helioplasmolites* is recorded from the Isfarin horizon.

The Kunzhak horizon has *Favosites*, *Squameofavosites*, *Pachyfavosites*, and *Alveolites* and is regarded as Upper Tiverian (Dubatolov and Chekhovich 1964). In the Kunzhak beds in the Zeravshan Range occur *Monograptus hercynicus* and *M. angustidens* and in the Turkestan Range *M.* ex gr. *hercynicus* (*fide* Dubatolov and Chekhovich 1964, p. 8). Nikiforova and Obut (1965, p. 489) refer to a recent find of *Monograptus hercynicus* with *Paranovakia geinitziana* Bouček and *P. obuti* Bouček in the western parts of the southern Tien Shan beds, and note that this gives correlation with the Upper Lochkovian of Bohemia (i.e. probably Lower and Middle Siegenian). Pavlova (1962, 1965) has described *Fasciphyllum kokshalicum* herefrom; it has two regular series of large subglobose dissepiments in its very slender corallites. Its walls are much thinner than those of *F. conglomeratum* Schluter.

From the Chinese Tien Shan Regnéll (1941, 1961) has described a fauna that could well be Tiverian from the Arpishmebulaq series of Chol-tagh: *Cystiphyllum*, *Teratophyllum*, *Favosites*, *Angopora*, *Thamnopora*, *Striatopora*, *Alveolites*, *Heliolites*, *Plasmopora*, and *Aulopora*.

Kazakhstan

In the geosynclinal regions of Central and South-east Kazakhstan in the Karaganda basin, the Dzhungarian Alatau and the L. Balkash region, the Akkan faunal complex is considered Ludlovian; Nikolaeva (*in* Bulvanker *et al.*, 1960) has described *Ketophyllum* (very like forms from the Eke marls of Gotland considered to be *Pilophyllum sp.*) solitary *Tryplasma* and *Holmophyllum*; Nikiforova and Obut (1965) list also *Calostylis*. The Tabulata are listed by Keller (1962) and Bondarenko (1962) as *Favosites*,

Mesofavosites, *Heliolites*, and *Propora*. Kovalevskiy *et al.* (1960) and Kovalevskiy (1965) described species of *Favosites*, *Multisolenia*, *Parastriatopora*, and *Halysites*.

From the probably Tiverian Aynasuy faunal complex, Nikolaeva (*in* Bulvanker *et al.* 1960) has described the new genera *Neobrachyelasma* and *Orthopaterophyllum* (to which she refers *Streptelasma australe* (Foerste) from the Ludlovian of the Yass District, N.S.W.), and colonial *Tryplasma* (as *Zelophyllum*). Nikiforova and Obut (1965) list also *Alleynia*, *Petraia*, *Chonophyllum*, *Oligophyllum*, *Kyphophyllum*, *Kodonophyllum*, *Neocystiphyllum*, and *Rhabdophyllum*, but of these I have found no descriptions. Keller (1962) listed *Favosites* and *Squameofavosites* herefrom and Bondarenko (1962) *Pseudoplasmopora* and *Heliolites*.

From the Burnak faunal complex above the Aynasuy complex, Keller (1962) listed *Plicatomurus* Chan (like *Pachyfavosites* but lacking fibrolamellar wall-structure); Bondarenko (1962) listed *Heliolites*, *Squameolites*, *Pseudoplasmopora*, and *Propora*. These two authors referred this complex to the middle and upper parts of the 'Upper Ludlow' (i.e. Tiverian). Descriptions of *Pseudoplasmopora* and *Squameolites* are given by Bondarenko (1963). *Pseudoplasmopora* differs from *Plasmopora* in having tubular, not dissepimental, coenenchyme. *Squameolites* has mixed tubular-dissepimental coenenchyme, and squamulae rather than septal spines. Bondarenko noted that *Plasmopora gippslandica* Chapman from the Lower Devonian of Victoria differed from the type species of *Pseudoplasmopora* only in having thickened walls to the coenenchymal tubules, this being regarded as a Devonian character.

From the Bogimbay complex, regarded as either uppermost Tiverian or basal Devonian, Keller listed *Favosites*, *Pachyfavosites*, *Squameofavosites*, *Axuolites* (Sharkova 1963*a*, a coenitid? genus), and *Caliapora*. Barskaya and Sharkova (1963) have discussed the Tabulata of the Ludlovian of the Tarbagatay Range, and Smelovskaya (1963) the Rugosa but I have not seen their works. Also Rukhin (1939) described Upper Silurian Tabulata from near Lake Balkhash, and Chan (1959) has founded *Plicatomurus* for favositids from the Upper Silurian (Tiverian) of Central Kazakhstan. Sharkova (1964) has described *Scoliopora* from the 'Ludlovian' of the Tarbagatay Range.

Altai–Sayan Geosynclinal Region

This region which includes the Rudny Altai, Southern Altai, Mountainous Altai, Salair, the flanks of the Kuznetsk and Minussinsk Basins, the Sayan and Tuva, was mobile during the Siluro–Devonian, for Upper Silurian and Lower Devonian beds are missing in many places. The best-known sequences are probably those of the Altai and the Salair.

In the Salair the Baskuskan suite (including the Mt. Glyadin beds with *Mesosolenia*) is probably Wenlockian but may include basal Ludlovian. The overlying Potapov suite, with *Cantrillia* [? = *Rhabdocyclus*] *eximia* Zheltonogova (1961) common, is considered Ludlovian (Nikiforova and Obut 1965). In the Altai the Chagyr suite is probably Ludlovian, and a rich fauna of Rugosa has been described by Zheltonogova (1961, 1965) and Cherepnina (1965). Tabulata (including Heliolitida and Chaetetida) have been described by Chernyshev (1951), Kraevskaya (1955*a*), Mironova (1961 *a*, *b*, 1965), Dzyubo and Mironova (1961) and Dzyubo (1961). The Chagyr coral fauna is *Entelophyllum* [as *Stereoxylodes* and *Petrozium*], *Phaulactis microcystis* (Zheltonogova), *Ryderophyllum* Cherepnina (1965), solitary '*Neobrachyelasma balchaschia* Nik.',

'*Dokophyllum*', *Circophyllum* and '*Neobrachyelasma*' *variabile* Zhelt. [these last two are fasciculate columnariids without dissepiments and with narrow peripheral stereozone], *Tabularia oblonga* [? = *Dendrostella*], *Soshkineolites* (a homeomorph of the L. Carb. *Carcinophyllum*), *Tryplasma*, species both solitary and fasciculate [as *Zelophyllum* and possibly as *Pycnostylus*?] and *Cystiphyllum* [including '*Holmophyllum*']; *Favosites*, *Mesofavosites*, *Mesosolenia*, *Striatopora*, *Parastriatopora*, *Laceripora cribrosa* Eichwald, *Taxopora altaica* Mironova, *Hillaepora*, *Heliolites tchengaensis* Mironova, *Schedohalysites pseudoorthopteroides* (Chern.), and *Halysites hamadai* Mironova. This fauna has endemic elements.

From the Gorny Altai Barskaya (1963) has described *Squameofavosites*, *Pachyfavosites*, *Heliolites pachycanaliculoides*, and *Favosites* in association with the halysitid *Hexismia*. She refers the deposits to the Upper Ludlovian, which, it seems, means Tiverian as now defined; so possibly *Hexismia* lasted into the Tiverian here, and may thus be the youngest halysitid.

In the Salair the Sukhaya suite lies between the Ludlovian Potapov suite and the Tom-Chumysh beds which are regarded by all who have worked on them as Tiverian. The corals of the Sukhaya suite that have been described by Zheltonogova (1961), Chernyshev (1951), Mironova (1960), Dzyubo and Mironova (1961) are the cerioid *Altaja*? *indistincta* Zhelt. (a homeomorph of *Lithostrotion* with a columella formed from a thin extension of the cardinal septum), *Dubrovia* (a solitary ptenophyllid? possibly of the *Spongophylloides perfectus* Wedekind group), *Stortophyllum*, *Squameofavosites* including *S. fungites* (Sok.), *Thamnopora khalfini* Dubatolov, *Striatopora salairica* Mironova, *Cladopora bella* Mironova, *Hillaepora spica* Mironova, *Heliolites*, and *Syringopora schmidti* var. This suite is commonly referred to the Tiverian; perhaps it is Skalian.

The Tom-Chumysh (ostracod) beds (= Tomskozavod suite) have a brachiopod fauna regarded as equivalent to that of the Lochkov of Czechoslovakia and the Tiverian of Podolia. Its Rugosa have been described by Bulvanker (1958), Zheltonogova (1961) and its Tabulata by many: Peetz (1901); Chernyshev (1951); Mironova (1960, 1961*b*), Dzyubo and Mironova (1961); Dubatolov (1959, 1963); Dubatolov and Chekhovich (1964), and Chudinova (1959, 1964).

Its rugosan fauna comprises *Phaulactis cyathophylloides* Ryder of Bulvanker, and '*Pilophyllum*' *insolitum* Zhelt. (both probably cyathophyllids like *Radiophyllum*), *Pilophyllum angustum* Zhelt. (possibly *ptenophyllid*), and *Dubrovia* also possibly ptenophyllid, the spongophyllids *Spongophyllum shearsbyi*? Chapman, cerioid *Neomphyma rosiformis* Zhelt. and tryplasmids, solitary and fasciculate. Of the Tabulata, *Squameofavosites* has the most numerous species, but species of *Dictyofavosites* (the first), *Favosites*, *Pachyfavosites*, *Striatopora*, *Parastriatopora*, *Thamnopora*, *Heliolites*, *Pachycanalicula*, and *Syringopora* are also characteristic. Dubatolov (1959) listed, as *Multisolenia*, *Palaeofavosites mirabilis* var. *baskuskanensis* Cherny. (1951). This may represent the youngest occurrence of *Multisolenia*. With these beds are correlated the Lochtev limestones of the Altai (Dubatolov 1962, Dubatolov and Chekhovich 1964) with *Favosites kogulaensis* (which is Lower Ludlow in Estonia), *Squameofavosites*, and *Parastriatopora*.

Siberian Platform

On the Siberian platform upper Silurian deposits are confined to the north-west flank of the Tungus syneclise and the south flank of the Anabar anteclise. *Parastriatopora*

and *Favosites* ex gr. *coreaniformis* occur (Sokolov and Tesakov 1963, Nikiforova and Obut 1965) and may be Ludlovian.

North-eastern U.S.S.R.

In the Verkhoyan–Chukotsk geosyncline of north-eastern U.S.S.R. Ivanovskiy (1965*b*) refers to Ludlovian *Lamprophyllum* from the R. Kolyma. The Tiverian? Nelyudum suite in the Ormulev Mountains in the basins of the R. Kolyma and R. Tirekhtya has abundant *Favosites socialis* Sokolov and Tesakov (1963) and new species of *Favosites*. Nikiforova and Obut (1965) refer to Tiverian beds with *Favosites* ex gr. *coreaniformis* Sok. and *Squameofavosites* in the basins of the Rivers Ormulev and Taskar, and beds with *F.* aff. *coreaniformis*, *Favosites*, and *Dictyofavosites* in the Sette-Daban Range. *F. socialis* occurs also in the Tiverian of the R. Pechora and the northern Urals. Earlier descriptions are by Chernyshev (1936, 1941*b*), Rukhin (1938*b*), and Nikolaeva (1936).

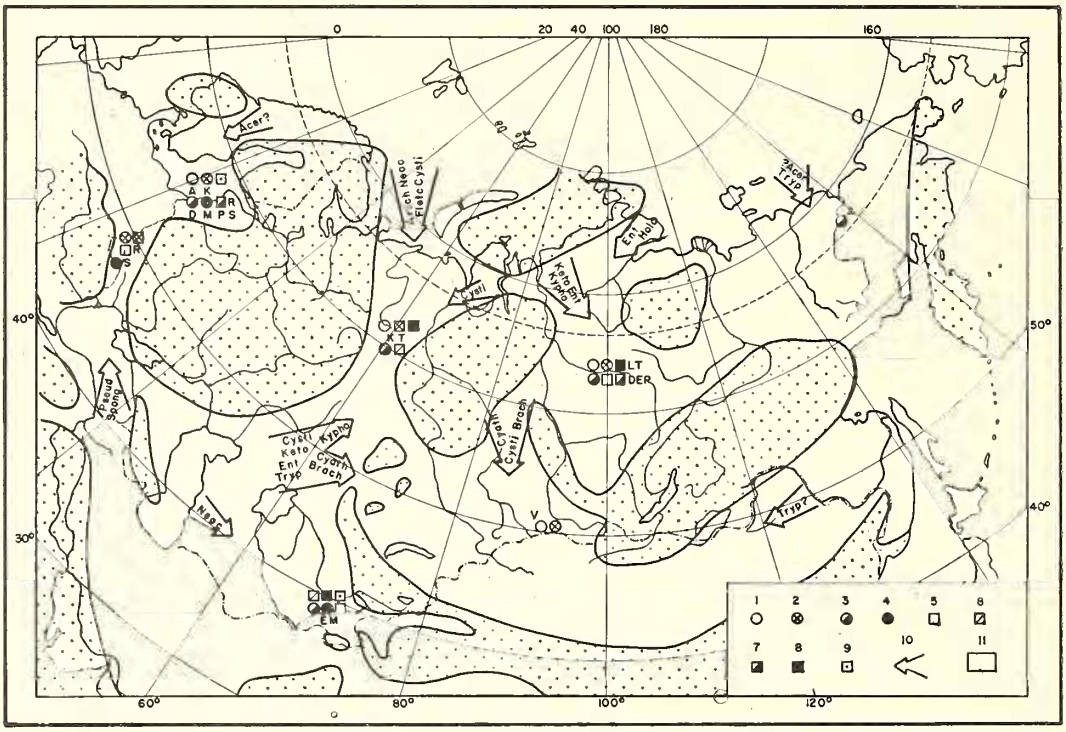
Faunal Analysis and Palaeozoogeography

Sokolov, Kovalevskiy, and Chekhovich (in Nikiforova and Obut 1965) state that the Ludlovian and Tiverian tabulatan faunas of the U.S.S.R. might be considered as forming one zoogeographic province and that regional differences are most likely due to facies. A similar opinion regarding the rugosan faunas is held by Kal'o (1965), who considered that in the pre-Ludlovian Silurian, two provinces were distinguishable, the European–central Asiatic, and the Siberian–American and that the degree of faunistic difference gradually decreased. Kal'o's map of the Wenlockian seas of the U.S.S.R. showing his suggested migration routes of the Rugosa is given in text-fig. 1.

Analysing the foregoing, we may say that the Ludlovian is characterized by genera with few exceptions (e.g. *Weissermelia*) relict from the Wenlockian, and consists nearly everywhere mainly of the Rugosa *Phaulactis*, *Entelophyllum*, *Weissermelia*, *Pilophyllum*, *Spongophylloides* of the *perfectus* (Wdkd.) group which are morphologically close to *Acanthophyllum*, numerous solitary and phaceloid tryplasmids, *Cystiphyllum*, *Holmophyllum*, and *Rhizophyllum*, with the Tabulata *Favosites*, *Palaeofavosites*, *Multisolenia*, *Parastriatopora*, *Alveolites*, *Coenites*, *Thecia*, *Laceripora* (the last?), *Heliolites*, *Propora*, *Halysites* (the last), *Aulopora*, and *Syringopora* and *Romingerella* (the first). In the Tien Shan *Squameofavosites* is recorded in an early occurrence, and in the Altai-Sayan, *Hillaepora*. Halysitids are not recorded from younger strata, except for *Hexismia sp.* from the 'Upper Ludlow' (i.e. presumably Tiverian) of the Mountainous Altai. Sokolov (1962*d*) concluded that for the wider correlation of Ludlovian (s.s.) deposits, of leading significance are *Favosites* ex gr. *forbesi*, *Thecia swinderniana*, *Mesolenia festivus*, and *Helioplasmolites* amongst others.

A small fauna distinguished in some regions and following this one includes, like the Skalian, '*Dokophyllum*', *Spongophylloides*, ?*Acanthophyllum*, solitary and fasciculate tryplasmids, species referred to *Holmophyllum* but some probably not of that genus, and *Cystiphyllum*. *Phaulactis* and *Weissermelia* are recorded but not illustrated. *Favosites* is predominant but rare *Squameofavosites* occur and *Thamnopora* with rare *Multisolenia* (the last?). *Thecostegites* enters in beds that may be Skalian in the Polar and Sub-polar Urals, with the Rugosan *Scyphophyllum* Strel'nikov. This fauna is not very different from that of the Ludlovian, with the possible exception that *Thecostegites* and *Thamnopora* (s.s.) have entered.

Nikiforova and Obut (1965) consider that in the early Ludlow regression of the seas began, reaching its maximum in Tiverian time, when, however, migration was still possible from Podolia via the Urals and South Caucasus to Central Asia. Their map is redrawn in text-fig. 2.



TEXT-FIG. 1. Directions of migration and geographical distribution of Wenlockian Rugosa.

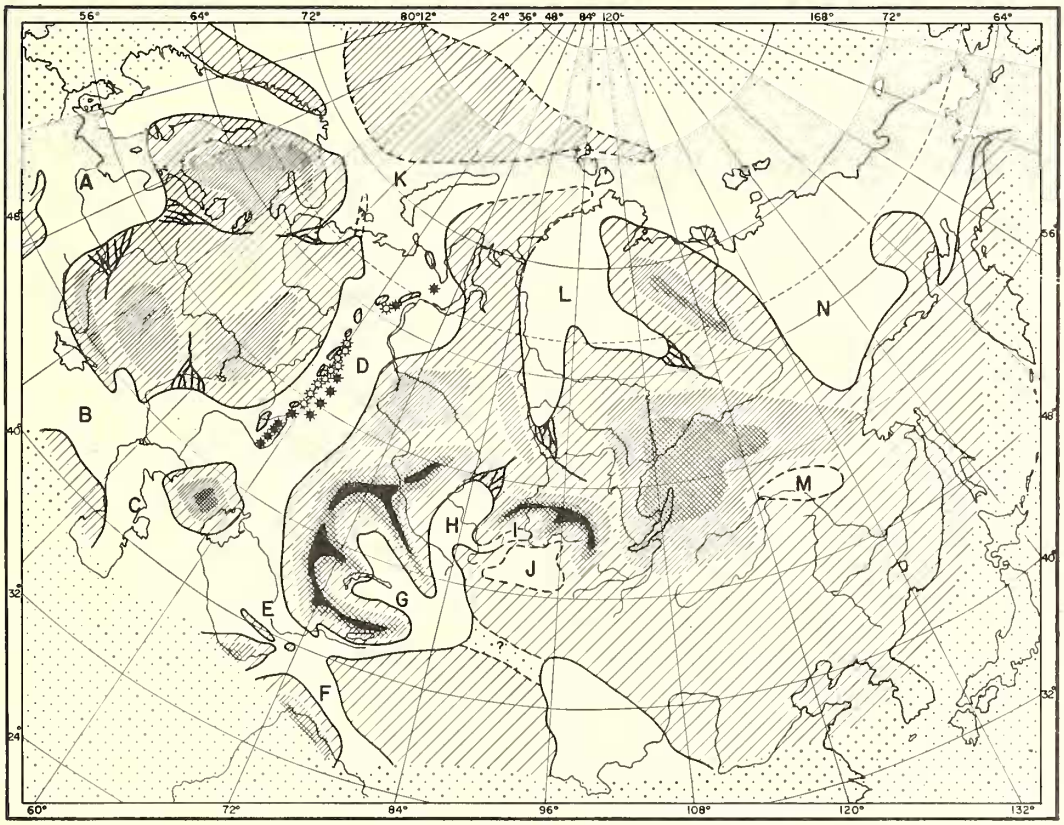
1, *Hedstromophyllum*; 2, '*Microplasma*'; 3, *Neocystiphyllum*; 4, *Phanlactis*; 5, *Cyathactis*; 6, *Holmophyllum*; 7, *Kyphophyllum*; 8, *Micula*; 9, *Zelophyllum*; 10, probable direction for the genera named in the arrow.

Acer (A), *Acervularia*; Arach, *Arachnophyllum*; Brach, *Brachyelasma*; Cyath, *Cyathactis*; Cysti, *Cystiphyllum*; D, *Dentilasma*; E, *Dinophyllum*; Ent, *Entelophyllum*; Fletc, *Fletcheria*; Keto, *Ketophyllum*; K, *Kodonophyllum*; Kyph, *Kyphophyllum*; L, *Lamprophyllum*; Neoc, *Neocystiphyllum*; Pseud (M), *Psendamplexus*; P, *Pycnactis*; R, *Rhizophyllum*; Spong, *Spongophylloides*; S, *Spongophyllum*; T, *Tabularia*; Tryp, *Tryplasma*.

I, Prebaltic; II, Podolia; III, Tadzhikistan; IV, Urals; V, Sayano–Altai; VI, Siberian platform; VII, NE. U.S.S.R. After Kal'o, 1965.

Tiverian faunas are sometimes divisible into two, but these taken together comprise *Neobrachyelasma* Nik., *Palaeocyathus* Foerste (= *Orthopaterophyllum* Nik.), '*Diplophyllum*' (a disphyllid?), *Spongophylloides* of the *perfectus* Wdkd. group, '*Fasciphyllum*' and numerous solitary tryplasmids and cystiphyllids, with *Favosites*, *Pachyfavosites* (the first?), *Squameofavosites*, *Dictyofavosites* (the first), *Multisolenia* (the last?), *Cladopora*, *Hillaepora*, *Thamnopora*, *Striatopora*, *Parastriatopora*, *Heliolites*, *Propora*, *Pseudoplasmopora*, *Squameolites*, *Syringopora*, and *Thecostegites*.

The boundary between the Silurian and Devonian seems to me to be possibly best taken at the base of the Tiverian and the base of the Lochkovian and the base of the Gedinnian, all of which appear in the continuing results of the Prague and Bonn symposia to represent practically the same point in time, which may well be part of Ludlow Bone Bed time, or perhaps the base of the Downtonian.



TEXT-FIG. 2. Tiverian Geography of Eurasia.

A, Palaeo-Baltic Sea; B, South European Sea; D, Ural Sea with volcanoes; E, Tien Shan Sea; F, Tadzhik Sea; G, Balkhash–Karaganda Sea; H, Altai Sea; I, Sayan Gulf: J, Tuva–Mongolian remnant basin; K, Novozemel Sea; L, Tungus Sea; M. Amur remnant basin; N, Verkhoyan Sea. Dotted area unknown or not analysed. Contouring of land is indicated by closeness of lining and mouths of rivers are shown. After Nikiforova and Obut, 1965.

The value of the Tabulata as indicators of the boundary between Silurian and Devonian has been argued by Mironova (1961*b*) on the one hand and by Dubatolov and Chekhovich (1964) on the other. Thus Dubatolov and Chekhovich consider that a sharper palaeontological boundary may be fixed in the Kuznetsk Basin, in Central Asia, and in Podolia at the top of the Tiverian and the base of the Krekov by the complete disappearance above this boundary of the genera *Palaeofavosites*, *Mesofavosites*, *Syringolites*, and *Propora* and by the appearance above it of *Pseudoroemeria*, *Roemeripora*, *Dendropora*, *Crassialveolites*, *Placocoenites*, and *Lecomptia*. Mironova noted that

the extinction of the halysitids and the multisolenids and the incoming in force of *Pachyfavosites*, *Dictyofavosites*, *Squameofavosites*, and *Thecostegites* gave a sharpness to the base of the Tiverian; however, rare exceptions occur, as noted above.

Both boundaries appear to have value in correlations within Eurasia, and may well be applicable elsewhere, regardless of where it is finally decided to draw the Silurian–Devonian boundary.

It should be noted that the only ptenophyllids figured from Tiverian strata are solitary corals referable to the *Spongophylloides perfectus* (Wdkd.) group of species which was present in the Ludlovian (and which may be *Acanthophyllum s.l.*) and the fasciculate '*Fasciphyllum*' *kokshalicum* Pavlova. There is a notable absence of *Xystriphyllum* and *Taimyrophyllum* as also of disphyllids (solitary, fasciculate, cerioid, and thamnastraeoid) and of *Pseudamplexus altaicus* (Dybowski).

It seems that the 'Upper Ludlovian' or 'Tiverian' of Asiatic Russia is broadly equivalent to the Lochkovian but the base and top of the faunal interval have still to be determined in the different regions. The equivalence of the Asiatic Tiverian with the stratotype Tiverian in Podolia is not yet certain either. If the Czortkow fishes are lower Gedinnian, as Tarlo thinks, the type Tiverian may be older than much of the Asiatic 'Tiverian'.

POST-TIVERIAN AND PRE-COUVINIAN

These are the faunas thought by this reviewer to be equivalent to the Pragian and Zlichovian of Czechoslovakia and to the upper Siegenian and Emsian of western Europe. None are described from Podolia.

Novaya Zemlya

A Lower Devonian assemblage from the horizon of the Morzhov Inlet has recently been described, the Rugosa by Kravtsov (1965) and the Tabulata by Smirnova (1965*b*). It consists of *Pseudamplexus altaicus* (Dyb.), *Acanthophyllum*, *Spongophyllum* [?] (solitary? or phaceloid), *Tryplasma*, *Stortophyllum* [?] and *Plasmophyllum* (*Plasmophyllum*) (as *Cystiphylloides*, *Nardophyllum*, and *Pseudomicroplasma*); and of *Favosites*, *Squameofavosites*, *Dictyofavosites*, *Syringolites* (?), *Pachyfavosites*, *Striatopora*, *Thamnopora*, *Caliapora*, *Alveolites*, *Alveolitella*, and *Syringopora*.

Urals

Soshkina (1937, 1941, 1949*a*, *b*, 1951, 1952), Spasskiy (1959), and Pavlova (1956) have described Lower Devonian Rugosa from the eastern and western slopes of the Urals and Porfir'ev (1937), Sokolov (1952*b*), and Yanet (1956, 1965) have described Tabulata. Chernyshev (1885, 1887, 1893) included descriptions of corals in his faunal papers. Some of the ages assigned in the early works have been modified in the later papers.

Correlation of the widely spread strata is still in progress and at present it does not seem that they can be precisely apportioned to the west European stages. The faunal lists of Spasskiy (1964) and Dubatolov (1964) have presumably taken account of increasing stratigraphic knowledge along the Urals, but unfortunately they do not enable me to refer precisely to the relevant illustrations of species. Spasskiy (1959) states that the following species have maximum distribution in the lower part of his post-Tiverian Lower Devonian of the eastern slopes (upper part of the Petropavlovsk formation):

Pseudamplexus quadripartitus (Soshk.), '*Acanthophyllum heterophyllum* E. & H.' and *Fasciphyllum petschoreuse* Soshk. These he called Gedinnian. The 'Coblenzian' beds with *Karpinskia conjugula* contain *Pseudamplexus* (solitary and weakly colonial species), *Chlamydophyllum tabulatum* (Soshk.), cerioid *Favistella minor* (Soshk.) and *F. massivum*, *Lyrielasma petschoreuse* (Soshk.) (these last two species at the top), *Neophyma originata* and *N. striata* S., *Acanthophyllum*, *Australophyllum*? (*as F. petschorense* pars.), *Xystriphyllum medianum* (S.), *Taimyrophyllum*, *Spongophyllum halysitoides*, *Tryplasma*, *Plasmophyllum* (*Plasmophyllum*) as *Pseudomicroplasma* and large *Rhizophyllum* occur; also *Favosites*, *Squameofavosites*, *Parastriatopora*, the *Cleistopora*-like *Riphaeolites* Yanet 1956, and *Syringopora*.

Central Asia

In the ranges of Turkestan, Gissar, Fergana, Alay, Nuratau, Kokschaaltau, and in the Pamir and Darwas, the post-Tiverian Lower Devonian Akkul suite contains numerous *Pseudamplexus* including *P. altaicus* (Dyb.) and *Acanthophyllum*, together with *Chlamydophyllum tabulatum* (Soshk.), *Neomphyma striata* Soshk., *Loyolophyllum*, *Spongophyllum halysitoides* Eth., fasciculate *Tryplasma* (as *Aphyllum*), *Rhizophyllum enorme*, and *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma*]. See Goryanov *et al.* (1961) and Spasskiy (1964). From the Dzhidalin suite of the Lower Devonian of S. Fergana Pavlova (1963, 1965) included in *Fasciphyllum* two cerioid species that could be *Xystriphyllum* and from the Akkul suite *Xystriphyllum prismaticum* (Soshk.) (see also Goryanov, 1962, 1963).

Dubatolov (1964) and Dubatolov and Chekhovich (1964) listed tabulatan species determined by Chekhovich but not yet illustrated from the Manak suite of Central Asia as of the genera *Favosites*, *Oculipora*, *Dictyofavosites*, *Squameofavosites*, *Pachyfavosites*, *Parastriatopora*, *Striatopora*, *Cladopora*, *Pseudoroemeria* Chekhovich (1960), *Helioplasma*, and *Heliolites*.

Leleshus (1964*b*) has described from Lower Devonian 'Coblenzian' beds with *Karpinskia conjugula* from the northern slopes of the Zeravshan Range, the new tabulatan genus *Rudakites*, like *Thamnopora* but with intermural increase. Listed with it are *Favosites*, *Squameofavosites*, *Dictyofavosites*, *Emmonsia*, *Pleurodictyum*, *Striatopora*, and *Crassialveolites* and the Rugosa *Pseudamplexus*, *Lyrielasma petschorense* (Soshk.), *Spongophyllum halysitoides* Erh., *Tryplasma*, and *Rhizophyllum enorme* Eth.

Goryanov (1963) considers that in the Southern Tien Shan the Lower Devonian fauna is not divisible into zones but is analogous to the Pragian of Czechoslovakia. He lists *Chlamydophyllum tabulatum* (Soshk.), *Lindstroemia spp.*, *Petraia spp.*, *Syringaxon spp.*, *Barrandeophyllum*, *Oligophyllum*, *Orthopaterophyllum* [= *Palaeocyathus*], *Pseudamplexus* [as *Mucophyllum*] and *P. altaicus*, *Kionelasma spp.*, *Kodonophyllum spp. Desmophyllum*, '*Entelophyllum*', *Pilophyllum*, *Acanthophyllum spp.*, *Ptenophyllum spp.*, *Spongophyllum halysitoides* Etheridge, *Loyolophyllum cresswelli* Chapman, *Fasciphyllum halliaforme*, *Lyrielasma ?petschoreuse* (Soshk.), *Xystriphyllum prismaticum* (Soshk.), *Aphyllum*, *Tabularia*, *Tryplasma*, cystiphylloids (under the names *Pseudomicroplasma*, *Wedekindophyllum*, and *Pseudodigonophyllum*), and *Rhizophyllum enorme* Eth.

Kazakhstan

Spasskiy (1965) described from rocks of the Dzhungarian Alatau which he ascribed to the Gedinnian but which may be Pragian, the new genus *Neokyphophyllum* [resembling

Pilophyllum] and listed *Orthopaterophyllum* [= *Palaeocyathus*], *Tryplasma devonianum* (Soshk.), *Tabularia*, *Favosites*, and *Heliolites*. As Coblenzian he listed *Barrandeophyllum*, *Orthopaterophyllum*, *Chlamydophyllum*, *Pseudamplexus*, and *Acanthophyllum*. From the northern sub-Balkash he listed (1964) *Xystriphyllum devonicum* (Bulv.). Sokolov (1962*d*) reported that Tabulata here and in some districts of Central Asia and parts of the Mongolo–Okhotsk geosyncline are rare and usually represented by *Pleurodictyum* and rare *Thamnopora* and *Trachypora*.

Altai–Sayan Geosynclinal Region

For this coral-rich region, the coral faunal sequences of the south-western margins of the Kuz Basin and the northern Salair may be taken herein as the standard of reference; the stratigraphic sequences in other parts of the region differ, but some suggested correlations are mentioned.

As seen above, the Tom-Chumysh beds are, by correlation with the *Monograptus hercynicus*-bearing *marginalis* beds of the Kunzhak suite of the Zeravshan Range, to be regarded as Lochkovian (i.e. within the range Gedinnian to base of early Upper Siegenian). Above them lie the Krekov beds.

The rugosan fauna of the Krekov beds has been described by Kraevskaya (1955*b*), Bulvanker (1958), Ivaniya (1957*a*, *b*; 1958*a*, *b*, *c*, *d*; 1960; 1961), and Zheltonogova and Ivaniya (1961) and consists of *Syringaxon*, *Petrozium* [?], *Pseudamplexus altaicus* (Dyb.) *Pseudotryplasma* Ivaniya (like *P. altaicus* but with sporadic large dissepiments), *Dendrostella columnaris* Zhelt. (as *Soshkinella*), *Tryplasma sociale* (Soshk.), *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma* and *Diplochone*], *Rhizophyllum gervillei* Bayle, and *R. enorme* Eth. See also Ivaniya (1965).

Tabulata of the Krekov beds have been described by Peetz (1901), Chernyshev (1951), Kraevskaya (1955*a*), Chudinova (1959, 1964), Dubatolov (1956, 1959, 1963, 1964), Dubatolov and Mironova (1961*a*, *b*, *c*), Dubatolov and Chekhovich (1964), Dubatolov and Smirnova (1964), and Mironova (1957, 1961*a*, *b*, *c*), and discussed by Khalfina (1956). *Favosites*, *Dictyofavosites*, *Squameofavosites*, rare *Pachyfavosites*, *Syringolites*? (last appearance?), *Parastriatopora*, *Thamnopora*, *Striatopora*, *Gracilopora* (first appearance), *Cladopora*, *Dendropora*, *Crassialveolites* (first appearance), *Coenites*, *Placocoenites*, *Lecomptia*, *Stelliporella*, *Heliolites*, *Pachycanalicula* (first appearance), *Syringopora*, and *Roemeripora* (first appearance) all occur. The first three genera named above are dominant.

The Malobachat beds with *Karpinskia conjugula* Tschernychev overlying the Krekov beds have Rugosa described mainly by Kraevskaya (1955*b*) and by Zheltonogova and Ivaniya (1961): *Syringaxon*, *Pseudamplexus altaicus* (Dyb.), the solitary disphyllid *Gurievskiella* Zhelt., *Neomphyma*, *Acanthophyllum* (as *Pseudochonophyllum*), *Lyrielasma*, *Xystriphyllum gorskii* (Bulv.), *Taimyrophyllum*, and *Tryplasma*. Tabulata, described in the same works as those of the Krekov beds are *Favosites*, *Pachyfavosites*, *Striatopora*, *Cladopora*, *Alveolites*, *Heliolites*, and *Syringopora* and for the most part the species are different from those of the Krekov beds. Bulvanker (1958) referred to the rugosan genus *Loyolophyllum*, a species (*breviseptata*) of the tabulatan *Roemeripora*. The transverse section she figured shows mural pores. Kraevskaya (1955*b*) referred to the undifferentiated Lower Devonian two cerioid small-celled *Spongophyllum spp.* See Ivaniya (1965).

Similar tabulatan faunas to those of the Krekov and Malobachat beds have been

described from the Mountainous Altai (Cherepnina and Dzyubo 1962, Dubatolov 1964).

Taimyr

Lower Devonian Rugosa and Tabulata of the Taimyr have been described by Chernyshev (1941*a*), Lower Devonian Rugosa by Kravtsov (1963) and Lower Devonian Tabulata by Dubatolov and Smirnova (1964) and Smirnova (1965*a*). Lists of species have been given by Spasskiy (1964), Dubatolov (1964), Smirnova (1965 *a*, *c*), and Kravtsov and Smirnova (1965).

The lowest of three post-Tiverian Lower Devonian coral faunas contains *Squameofavosites*, *Parastriatopora*, and *Striatopora*. The second has *Pseudamplexus altaicus* (Dyb.), *Tryplasma devonianum* (Soshk.), *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma* and *Zonophyllum spp.*], *Tabularia* [?], *Zmeinogorskia* [= *Heterophentis*?], *Aulacophyllum* [?], *Taimyrophyllum speciosum* Chernyshev and presumably also *Disphyllum*? *planivesiculosum* (Chern.) together with *Favosites kolymensis* Chern. and *F. spp.*, *Squameofavosites*, *Parastriatopora*, *Striatopora*, *Caliapora*, *Pleurodictyum*?, and *Syringopora*. The highest has *Tryplasma devonianum* (Soshk.), *Plasmophyllum* (*Plasmophyllum*) [as *Pseudozonophyllum*] and *Xystriphyllum taimyricum* (Kravtsov), with *Squameofavosites*, *Thamnopora taimyrica* (Chern.), and *Alveolitella* (first appearance).

Transbaikalia and the Mongolo–Okhotsk (Amur) Geosyncline

In the Upper Amur, the Bolshenever suite is considered Lower Devonian, possibly later Lower Devonian. Spasskiy (1960*b*) described *Barrandeophyllum perplexum* Pocta and *Lindstroemia minima*; Dubatolov (1964) listed *Favosites* and *Pleurodictyum*. The younger Imachin suite, possibly ranging from the late Lower into the Middle Devonian (Dubatolov 1964) or possibly entirely Eifelian (Spasskiy 1960*b*, 1964), contains '*Zaphrentis*', *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma* and *Lythophyllum*] and *Cyathophyllum* (*Peripaedium*) *spinulosum* (Soshk.). This latter species seems from Spasskiy's figures to differ from Soshkina's type and to be a cyathophyllid quite close to *Radiophyllum arborescens* Hill from the Emsian? Mt. Etna limestone of Queensland. Tabulata are *Favosites*, *Squameofavosites*, *Crenulipora*, *Thamnopora*, and *Tyrganolites* —this last genus normally being an indicator of Middle Devonian.

The Lower Devonian Il'dikan suite of eastern Transbaikalia contains *Favosites* and *Striatopora* (Dubatolov 1964) and, near the Gazimov works, *Barrandeophyllum*, *Tabulophyllum* [?] *sp.*, *Pseudamplexus fascicularis* (Soshk.) *Favistella*, and the endemic, solitary *Gazimuria ildicanica* Spasskiy (1960*b*). Spasskiy (1964) suggests that the upper part of the Il'dikan suite contains '*Stenophyllum*' *sp.* The Blagodat suite around Nerchin contains *Lindstroemia minima* Spasskiy (1960*b*), *Favosites*, *Parastriatopora*, *Alveolitella*, and *Placocoenites* (Rukhin 1936, Dubatolov 1964).

North-eastern U.S.S.R.

From the upper part of the Upper Silurian of the R. Kolyma, Rukhin (1938*b*) has established *Kozlowiaphyllum* which Ivanovskiy (1965*b*) has considered a synonym of *Temniphyllum* Soshkina and regarded as Wenlockian. From the Lower Devonian, Rukhin described *Entelophylloides inequalis* (Hall) which is possibly the same genus as *Xystriphyllum*. Bulvanker (1965) figured from the undivided Lower Devonian of the

Ormulev region *Acanthophyllum mansfieldense* (Dun), *Taimyrophyllum colymense* Bulv., *Pseudamplexus altaicus* (Dyb.), and *Plasmophyllum* (*Plasmophyllum*) aff. *nesterowskii* (Peetz). From beds regarded as transitional from Lower Devonian to Eifelian she figured *Acanthophyllum spp.*, *Taimyrophyllum cariuatum* Bulv., and *P. altaicus*. Other descriptions are by Bulvanker (1948). Spasskiy (1964) listed *Tryplasma maximum* (Chern.) additionally in a similar fauna from the Verkhoyan.

Tabulata have been described by Chernyshev (1936), Rukhin (1938*b*), and Dubatolov and Spasskiy (1964*b*) and Dubatolov (1964) has supplied lists of Lower Devonian forms. The distinctive feature of the north-east Siberian fauna is the presence of *Favosites socialis* Sok. and Tes. and of great numbers of local species of *Parastriatopora*, *Striatopora*, *Cladopora*, *Alveolitella* and *Caliapora*, the endemic *Yacutipora* (like *Parastriatopora* but with trabecular wall thickening in the peripheral part of the branch, and long narrow pore canals with diaphragms), and the absence of heliolitids. *Dictyofavosites* and *Squameofavosites* occur also in the Sette-Daban and Tas Khayakhtakh regions.

Faunal Analysis and Palaeozoogeography

Reviewing the above, we see that the Altai-Sayan faunas are the best illustrated and further that in the Salair there is a proved sequence of faunas from that of the Tom-Chumysh beds, through the Krekov beds and into the Malobachat beds. If we accept the correlation of the Tom-Chumysh beds with the Kunzhak beds of the Zeravshan Range in the Tien Shan, as indeed seems completely reasonable, we then have the probability that the Tom-Chumysh beds are Upper Lochkovian, since *Monograptus hercynicus*, *Paranowakia geinitziana* Bouček and *P. obuti* Bouček are reported from the Kunzhak beds, though I have found no illustrations to substantiate the identifications. The Krekov beds may then well be Pragian, within the range Upper Siegenian–Lower Emsian and the Malobachat beds may possibly be either Lower Emsian or Zlichovian. Such correlations can be only very tentative at present.

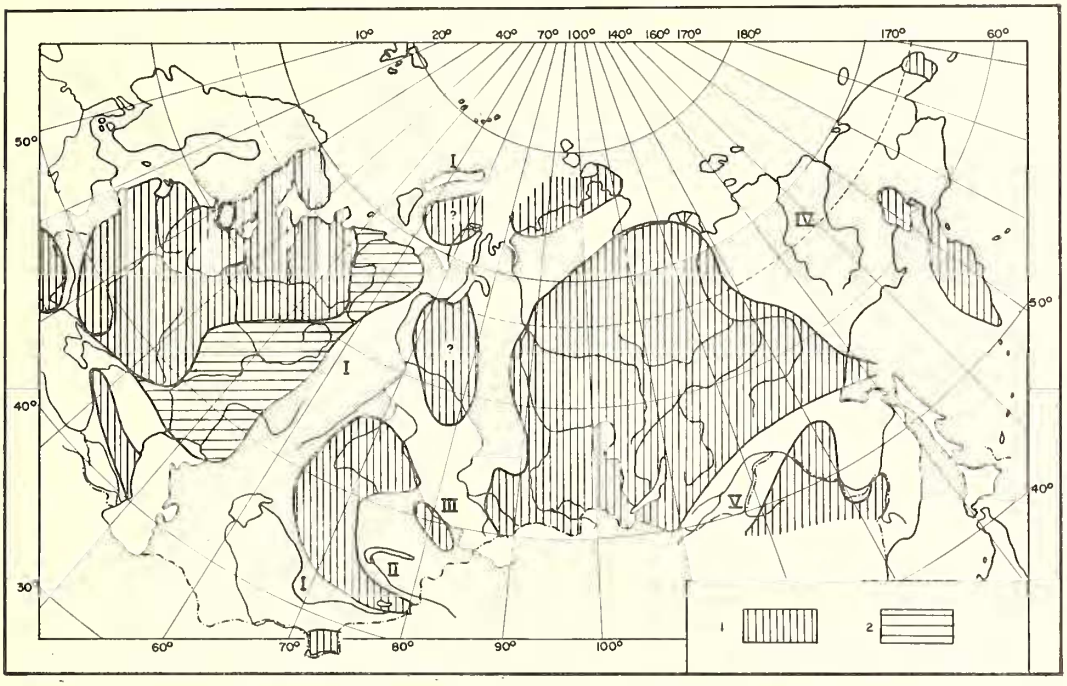
The Krekov fauna as listed above, is very similar to the Pragian upper Konieprus fauna of Czechoslovakia, differing mainly in the absence of ptenophyllids, but ptenophyllids are found in force accompanying *Pseudamplexus altaicus* and tryplasmids, *Rhizophyllum enorme* and *Roemeripora* in the overlying Malobachat beds, where '*Pseudochonophyllum*', phaceloid *Neomphyma*, cerioid *Xystriphyllum*, and thamnastraeoid *Taimyrophyllum* occur (Zheltonogova and Ivaniya 1961), together with *Spongophyllum halysitoides* Eth. and the solitary disphyllid *Gurievskiella* Zhelt. We are left wondering whether the absence of ptenophyllids and disphyllids in the Krekov beds and their presence in the overlying Malobachat beds is due solely to the difference in age.

The Krekov plus Malobachat beds and their correlatives in Asia are clearly distinguished from the underlying Tiverian by an assemblage of the Rugosa *Pseudamplexus* (especially *altaicus*), †*Gurievskiella*, †*Loyolophyllum*, †*Neomphyma*, *Acanthophyllum* (*s.l.*), †*Lyrielasma*, †*Xystriphyllum*, †*Taimyrophyllum*, *Spongophyllum*, *Tryplasma*, *Plasmophyllum* (*Plasmophyllum*) and *Rhizophyllum*, together with the Tabulata *Favosites*, *Dictyofavosites*, *Squameofavosites*, *Pachyfavosites*, *Thamnopora*, †*Gracilopora*, and †*Roemeripora*. The genera marked † are not known in older beds in Asia.

The chief character of the tabulatan fauna is the exceptionally wide and rich development of the squamulate favositids *Squameofavosites* and *Dictyofavosites*, many of the species having profuse mural pores; also notable is the wall thickening of the branching

favositids *Parastriatopora* and *Striatopora*; the *Thamnopora* and *Cladopora* species have relatively thin walls, and the heliolitids show some thickening of the walls of their interstitial tubuli; at the same time the alveolitids differ from Silurian representatives in the thickening of their walls.

Dubatolov's (1964) and Spasskiy's (1964) maps, here reproduced as text-figs. 3 and 4, show their views on the zoogeographic provinces of the Lower and Middle Devonian, Spasskiy's map showing also the reefs and his deduction on the position of the equator.



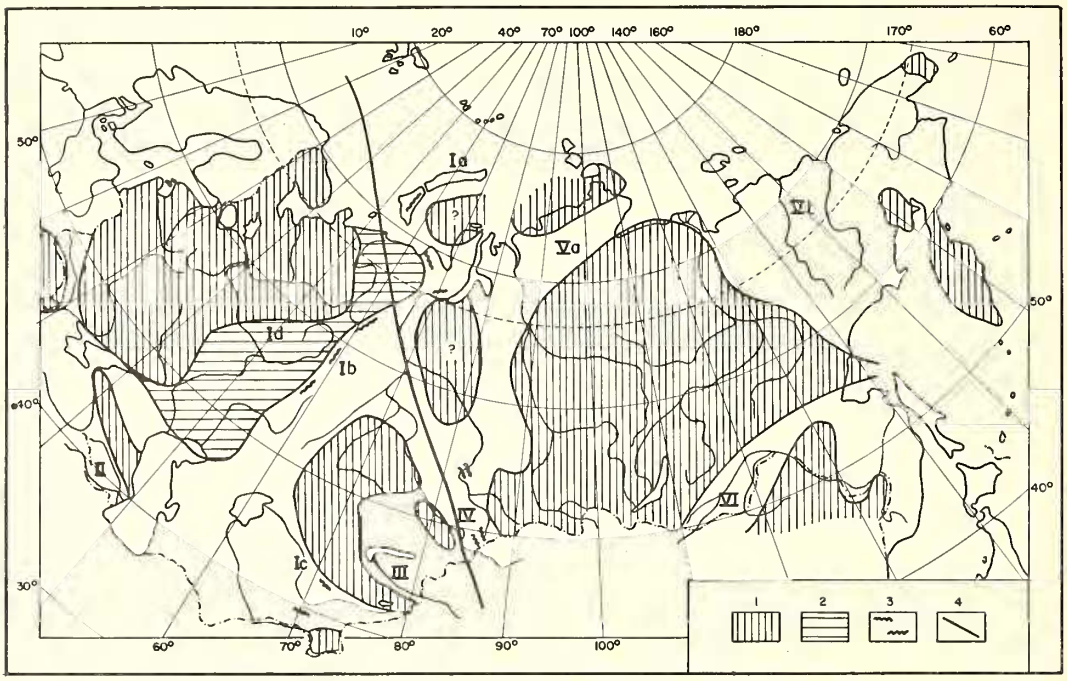
TEXT-FIG. 3. Palaeozoogeographic provinces in the Early and Middle Devonian, based mainly on the Tabulata.

1, land; 2, epicontinental sea. Provinces: I, Uralo–Tien Shan; II, Dzhungaro–Balkhash; III, Altai–Sayan; IV, Indigiro–Kolyma; V, Mongolo–Okhotsk. After Dubatolov, 1964.

In my view, however, the distribution of the reefs can be equally well explained by climatic and temperature difference induced by the Devonian relation of continents and oceans, with the continental nuclei in their present position relative to the poles and to the present direction of the axis of rotation of the earth.

The Uralo–Tien Shan Province including Novaya Zemlya and the Taimyr with *Pseudamplexus*, *Chlamydophyllum*, *Tryplasma*, *Acanthophyllum*, and *Favosites* dominant, and with *Striatopora* and *Cladopora* present is considered continuous with that of Western Europe via Asia Minor and the Mediterranean region. The Altai–Sayan Province is characterized by *Tryplasma*, *Acanthophyllum*, and in the younger beds by ptenophyllids, and by the dominance of *Squameofavosites*, *Dictyofavosites*, and *Plicatomurus*, and the presence of *Cleistopora*, *Placocoenites*, and *Lecomptia*. The Dzhungarian–Balkash province has, as known at present, only small solitary non-

dissepimented Rugosa (due to facies?); the Tabulata, though also poorly known, suggest to Dubatolov (1964) sharp regional differentiation. The Mongolo–Okhotsk province appears characterized by the absence of *Tryplasma*, *Acanthophyllum*, *Striatopora*, *Thamnopora*, *Cladopora*, *Alveolites*, and *Heliolites*, and the presence of distinctive species of *Pleurodictyum*, *Favosites*, and *Sqnameofavosites*. The Indigiro–Kolyma Province



TEXT-FIG. 4. Palaeozoogeographic provinces in the Early and Middle Devonian, based mainly on the Rugosa.

1, land; 2, epicontinental sea; 3, hercynian reefs; 4, position of the equator suggested by Spasskiy. Provinces: I, Uralo–Tien Shan; a, Pay-Khoy–Novozemel region; b, Ural region; c, Central-Asian region; d, Volgo–Timan region. II, Caucasus region of the Mediterranean province. III, Dzhungaro–Balkhash. IV, Altai–Sayan. V, Indigiro–Kolyma; a, Taymyr region; b, Kolyma region. VI, Mongolo–Okhotsk. After Spasskiy, 1965.

shares a rugosan complex with the Taimyr region—*Taimyrophyllum speciosum* and *Tryplasma maximum* being characteristic; its tabulatan fauna is distinct, characterized by an abundance of branching *Favosites* ex gr. *socialis* and the endemic *Yacutipora*.

COUVINIAN

Russian formations and faunal horizons referred to the 'Eifelian' have been so referred by general faunal correlation. According to Sokolov (1962*d*) the common usage of 'Eifelian' in the U.S.S.R. includes the Eifelian proper and the *cultrijugatus* beds, and is thus presumably equivalent to the Couvinian of Belgian geologists. They lie below *Stringocephalus*-bearing beds referred to the Givetian, contain *Conchidiella* in the greater, upper part and, in some regions, *Paraspirifer* in the lower part and lie above beds

bearing *Karpinskia conjugula* which have been generally referred to the Coblenzian, but which in her review of Devonian correlations Rzhonsnitskaya (1962) has called Lower Emsian and Upper Pragian.

In the same review Rzhonsnitskaya has referred the *Paraspirifer* beds (= zone of *Favosites regularissinus* of the eastern slopes of the Urals and the Salairkin beds of the Kuznetsk sequence) to the Zlichovian which she accepted as Upper Emsian but regarded as equal to the Assise de Bure of Belgium and considered Middle Devonian but pre-Eifelian. However, in most current Russian work the east Uralian zone of *F. regularissinus* and the Salairkin beds are called Lower Eifelian.

Unfortunately the Russian zonal brachiopods do not occur in Western Europe, but detailed work on brachiopod groups such as the Atrypida, as well as on the goniatites, conodonts, tentaculites, and corals now in progress must eventually give precise correlations both within the U.S.S.R. and with the standard sequences of Western Europe. In the meantime we must regard the Salairkin beds and their correlates as possibly Upper Emsian or possibly Lower Couvinian.

Novaya Zemlya, Vaygach Island, and Pay-Khoy

Spasskiy (1964) and Dubatolov (1964) listed from the 'early Eifelian' of this northern region *Barrandeophyllum*, *Pseudamplexus*, *Chlamydophyllum* (as *Zelophyllia*), *Loyolophyllum*, *Neocolumnaria vagranensis* Soshk., *Spongophyllum halysitoides* Eth., *Acanthophyllum*, *Neomphyma striata* Soshk., *Fasciphyllum orientale* Soshk., *Xystriphyllum uralicum* (Soshk.), *Tryplasma* and *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma*], and the Tabulata *Favosites regularissimus* and *Pachyfavosites*.

From the later Eifelian Spasskiy (1964) listed *Zelophyllia*, *Cyathophyllum* (*Peripaedium*) *spinulosum* (Soshk.), '*Campophyllum*' *soetenicum* Schlüter, '*Charactophyllum*' *antiquum* Soshkina, *Favistella floriformis* (Soshk.), *Neomphyma striata*, *Tryplasma*, *Plasmophyllum* (*Plasmophyllum*) [as *Lythophyllum*, *Zonophyllum*, *Pseudozonophyllum*], *P.* (*Mesophyllum*) [as *Digonophyllum*] and *Calceola*. Dubatolov (1964) listed *Favosites* ex gr. *goldfussi* d'Orb. and *Syringopora eifeliensis* Schlüter. Descriptive papers are scanty (Chernyshev 1937*a*, 1938*a*, *b*).

Urals

The 'Eifelian' of the western slopes of the Urals, earlier taken to comprise the Takatin, Vanyashkin, and Vyazov beds and their correlatives has been augmented by the overlying *Calceola* and Biya beds which were removed from the Givetian by resolution of a conference held in Sverdlovsk in 1957 (Spasskiy 1960*a*). Similarly the 'Eifelian' of the eastern slopes has been augmented (Spasskiy 1959; Khodalevich *et al.* 1959) by the highest of the beds with *Conchidiella bashkirica* (D_2 2a and D_2 2b of Andronov) previously considered Givetian; *Stringocephalus burtini* had been reported from them but this record was doubted by Khodalevich *et al.* (1959). Also some of the sequences considered Lower Devonian or older by Soshkina are considered Eifelian by Spasskiy (1960*a*).

The correlation of the eastern sections one with another and of the western sections one with another and of the eastern with the western (including the type localities of Soshkina's species *Zelophyllia tabulata*, *Tryplasma magnum*, *Astrophyllum irgizlense*, *Neomphyma striata*, and *Fasciphyllum petschorense*), is still under discussion, the main

point at issue being how much of the sequence on either side should be regarded as lower and how much upper 'Eifelian'. Spasskiy (1955, 1959, 1960*a*, 1964) treated as lower Eifelian on the western slopes, the Takatin, Vanyashkin, and Vyazov beds and on the eastern slopes, the horizons D_2 1 a–e of Andronov; he considered the Yaiva Band, the *Calceola* Beds, and the Biya beds of the western slopes as Upper Eifelian as also the Bogoslovsky bauxite horizon and overlying conchiferous limestone of the eastern slopes. Yanet (*in* Khodalevich *et al.* 1959) zoned the Eifelian of the eastern slopes into a lower zone of *F. regularissimus* and an upper *Conchidiella* zone; but this division does not necessarily coincide with Spasskiy's.

Khodalevich *et al.* (1959) considered the *F. regularissimus* zone to correlate with the Salairkin beds of the Kuznetsk sequences and the *Conchidiella* zone with the Shandin beds of that sequence.

Using Spasskiy's early and late Eifelian for the Rugosa, and for the Tabulata of the western slopes, and Dubatolov's (1964) division (following Yanet *in* Khodalevich 1959) for the eastern slopes, it is possible to distinguish an early Couvinian from a late Couvinian fauna. Both are clearly distinct from the 'Coblenzian' fauna and both contain many species in common, but there are a few generic and more specific differences. Taking the Rugosa first:

Continuing into the early Middle Devonian (*sensu* Spasskiy) from the 'Coblenzian' are *Pseudamplexus*, *Chlamydophyllum tabulatum* (Soshk.), *Favistella*, *Dendrostella*, *Loyolophyllum*, *Fasciphyllum*, *Acanthophyllum*, *Neomphyma striata* Soshk., *Lyrielasma petschorense* (Soshk.), *Xystriphyllum*, *Spongophyllum halysitoides* Eth., *Tryplasma* and *Plasmophyllum* (*Plasmophyllum*). Newly appearing in the early Middle Devonian (*sensu* Spasskiy) are *Pseudopetraia*, *Barrandeophyllum*, *Nalivkinella*, *Keriophylloides astreiformis* (Soshk.), *Peneckiella porfirievi* Spasskiy, *Trapezophyllum breviseptatum* (Yoh), '*Megaphyllum*' *juresanense* (Soshk.), '*Charactophyllum*' *antiquum* Soshkina, *Neocolumnaria*, *Stringophyllum*, *Plasmophyllum* (*Mesophyllum*), and *Calceola* (with thickened tabellae). This represents a very considerable enrichment of the late Lower Devonian fauna from which *Rhizophyllum* has nearly everywhere disappeared. In the late Eifelian occur the following genera not listed earlier from the Urals: *Cyathophyllum* (*Peripaedium*) *spinulosum* (Soshk.), *Thamnophyllum*, *Plasmophyllum* (*Plasmophyllum*) [as *Pseudozonophyllum*, *Pseudomicroplasma*, and *Lythophyllum*], *P.* (*Mesophyllum*) [as *Arcophyllum*, *Uralophyllum*, and *Glossophyllum*], '*Campophyllum*' *soetenicum* Schlüter and *Calceola* (without tabellae). A large number of species is common to both lower and upper parts of the Eifelian; however, *Pseudamplexus* is not reported from the Upper Eifelian of the Urals. From the undifferentiated Eifelian of the eastern slopes, Vaganova (*in* Khodalevich *et al.* 1959) figured solitary disphyllids (as *Tabulophyllum* and *Tortophyllum*), the phaceloid disphyllids *Paradisphyllum simplex* (Vaganova), *P. caespitosum* (Vag.), and the cerioid '*Hexagonaria*' *massiva* (Vag.). The Rugosa have been described by Bulvanker (1934), Soshkina (1936, 1937, 1941, 1949*a*, *b*, 1951, 1952), Markov (1941), Spasskiy (1955, 1959), and Pavlova (1965). Earlier papers on Devonian corals from the Urals are by Bogatyrev (1899), Chernyshev (1885, 1887, 1893), and Lebedev (1902).

The tabulatan fauna described by Yanet *in* Khodalevich (1959) from the Lower Eifelian *Favosites regularissimus* zone of the eastern slopes comprised *Favosites*, *Pachyfavosites*, *Squameofavosites*, *Thamnopora*, *Cladopora*, *Alveolites*, *Caliapora*, *Heliolites*, and *Syringopora*. Their stratigraphic significance was discussed by Yanet (1960). Tabulata

described by Sokolov (1952*b*) from the Vyazov beds of the western slopes are species of *Pachyfavosites*, *Crassialveolites*, and *Caliapora*. For the *Calceola* and Biya beds of the western slopes Sokolov has described (1952*b*) or recorded (1962*d*) species of *Favosites* including *F. goldfussi*, *Pachyfavosites*, *Enmonsia*, *Oculipora*, *Thamnopora*, *Striatopora*, *Cladopora*, *Corolites*, *Alveolites*, *Crassialveolites*, *Caliapora*, *Coenites*, *Natalophyllum*, and *Syringopora* (usually large). Yanet described from the Upper Eifelian *Conchidiella* zone of the eastern slopes species of the genera *Chaetetes*, *Favosites*, *Pachyfavosites*, *Enmonsia*, *Thamnopora*, *Cladopora*, *Alveolites*, *Alveolitella*, *Crassialveolites*, *Caliapora*, *Heliolites*, and *Syringopora*.

Russian Platform

Ermakova (1960, 1964, 1965) described from bore-cores from the south-eastern part of the platform species of several of the rugosan and tabulatan genera listed for the *Calceola* and Biya beds above and in addition the new phacelo-cerioid rugosan genus *Breviseptophyllum*.

Armenia

Soshkina (1952) figured *Macgeea murchisoni* (Penecke), *Cyathophyllum* (*Peripaedium*) *spinulosum* (Soshk.), *Fasciphyllum orientale* Soshk., *Acanthophyllum* (as *Pseudochonophyllum*), *Plasmophyllum* (as *Lythophyllum*) from Armenian beds that she referred to the Eifelian. Ulitina (1963) has described *Plasmophyllum* species (as *Nardophyllum*) from the Rivers Arpa and Araks. In his Eifelian list Spasskiy (1964) included *Peneckiella bashkirica* (Spasskiy). Chudinova is working on the Tabulata of the Eifelian Volchevorot beds, including *Favosites goldfussi*, *Thamnopora*, *Alveolitella*, and *Heliolites*. Frech (*in* Frech and Arthaber 1900) described other corals some of which may have been Eifelian.

Central Asia

From the Eifelian mainly reef limestones of this region in Fergana, Tadzhikistan, the Pamir, and Darwas, Spasskiy (1964) listed †*Lindstroemia*, *Pseudopetraia*, *Barrandeophyllum*, **Oligophyllum*, **Tabulophyllum rotundum* Spasskiy, **Calceola*, †*Pseudamplexus*, *Chlamydophyllum* [as *Zelophyllia*] **Zmeinogorskia sagsaika* Spasskiy, *Tryplasma devonianum*, *Plasmophyllum* (*Plasmophyllum*), *Acanthophyllum*, **Campophyllum soetenicum* Schluter, **Heliophyllum halli*, **Favistella symbiotica*, **F. vulgaris* (Soshk.), *Spongophyllum halysitoides*, **Xystriphyllum altum* (Soshk.), *X.* **devonicum* (Bulv.), *Grypophyllum striatum* (Soshk.), †*Loyolophyllum*, cerioid and phaceloid *Fasciphyllum*, and *Neocolumnaria*. Of these the ones marked * are from the upper parts only and those marked † from the lower parts only. Dubatolov (1964) listed from the Eifelian tabulatan fauna, which like the rugosan fauna is largely undescribed, *Favosites*, †*Pachyfavosites*, *Oculipora*, †*Squameofavosites*, **Caliapora* and *Heliolites*.

Goryanov (1963), working in S. Fergana, distinguished three rugosan assemblage zones; from the first two, the *Acanthophyllum–Ptenophyllum* zone and the *Columnaria–Fasciphyllum* zone of the lower and middle parts of the Katran suite and which he regarded as correlative with the Takatin Vanyashkan and Vyazov beds of the Urals and the Salairkin beds of the margin of the Kuzbas, he listed but has not figured *Chlamydophyllum tabulatum* (Soshk.), *Petraia*, *Syringaxon*, *Barrandeophyllum*, *Heliophyllum*

spongiosum Schlüter, '*H*'. cf. *antiquum* (Soshk.), *Loyolophyllum cresswelli*, *Neocolumnaria vagranensis* (Soshk.), *Acanthophyllum*, *Neomphyma striata* (Soshk.), *Fasciphyllum halliaforme*, *F. orientale*, and *F. conglomeratum* Schlüter, *Xystriphyllum spp.* (as *Stenophyllum*), and no *Plasmophyllum*.

From the *Stenophyllum–Zonophyllum* zone which he correlated with the *Calceola* and Biya beds of the western Urals, and the Shandin beds of the Salair, he listed *Nalivkinella*, *Barrandeophyllum*, *Mucophyllum biseptatum* (Soshk.), *Grypophyllum*, *Xystriphyllum*, *Fasciphyllum*, *Columnaria*, '*Campophyllum*' *soetenicum*, '*Heliophyllum spongiosum* (Schlüter)', '*H*' *antiquum* (Soshk.) and *Plasmophyllum* (*Plasmophyllum*) [as *Zonophyllum*], and *P.* (*Mesophyllum*) [as *Digonophyllum*].

Kazakhstan

Spasskiy (1965) described from rocks considered Eifelian in the Dzhungarian Alatau, the new genus *Multicarinophyllum*, '*Bethanyphyllum*' *maximum* Spasskiy, and *Spongophyllum gemmatum* Spasskiy and listed *Barrandeophyllum*, *Orthopaterophyllum*, *Ridderia*, *Acanthophyllum*, *Stringophyllum* and *Plasmophyllum* (*Mesophyllum*) [as *Digonophyllum*], and *Favosites*, *Thamnopora*, and *Tyrganolites*. His 1964 list included *Eddastrea grandis* (Dun) (= *Taimyrophyllum*). From the northern sub-Balkash Dubatolov (1964) listed the undescribed late Eifelian tabulatan fauna as species of *Squameofavosites*, *Thamnopora*, *Cladopora*, *Coenites*, *Placocoenites*, *Tyrganolites*, *Stelliporella*, and *Syringopora* and Spasskiy (1964) listed *Thamnophyllum*, *Campophyllum maximum* Spasskiy, *Heliophyllum halli* E. & H., and *Cyathophyllum* (*Peripaedium*) *spinulosum* (Soshk.). I have seen no figures of this interesting fauna, which presumably is late Eifelian. Sharkova (1963*b*) has described the middle Devonian Tabulata of the Tarbagatay Range.

Altai–Sayan Geosynclinal Region

The Salairkin beds with *Paraspirifer gurievskensis* were considered Zlichovian by Rzhonsnitskaya (1962) and Upper Emsian; but she included these correlatives in the Middle Devonian with the Assise de Bure of the Ardenne, which she regarded as older than the Eifelian. Dubatolov (1964) lists the Salairkin beds as early Eifelian.

Rugosa of the standard sections have been described by Peetz (1901), Bulvanker (1958), Kraevskaya (1955*b*), and Zheltonogova and Ivaniya (1961) and comprise *Thamnophyllum*, *Disphyllum*, *Loyolophyllum*, *Acanthophyllum*, *Xystriphyllum massivum* (Bulv.), *X. submassivum* (Bulv., with columella), *X. devonicum* (Bulv.) and *X. gorskii* (Bulv.), '*Grypophyllum*' *gracile* (Soshk.), *Spongophyllum* [or? *Australophyllum*], *Plasmophyllum* (*Plasmophyllum*) (as *Pseudomicroplasma*). The species referred to *Iowaphyllum* in Zheltonogova and Ivaniya (1961) seems rather to be *Endophyllum*—possibly the earliest of that genus. See also Ivaniya (1965).

Spasskiy (1960*c*, *d*) described some Rugosa from the southern Altai and neighbouring regions, including a small fauna from the lower part of the Lower Kultabar suite which may be Lower Devonian, but possibly is as young as the Salairkin faunas of the Salair.

Tabulata from the Salairkin beds have been described by Peetz (1901), Chernyshev (1951), Chudinova (1959, 1964), Dubatolov (1956*a*, *b*, *c*, 1959, 1962, 1963, 1964), Dubatolov and Mironova (1961 *a*, *b*, *c*), Dubatolov and Chekhovich (1964), and Dubatolov and Smirnova (1964). They comprise *Favosites regularissimus* Yanet and other species of *Favosites*, rare *Squameofavosites*, *Pachyfavosites polymorphus* (Goldfuss),

Gephuropora, *Striatopora*, *Gracilopora*, *Thamnopora*, *Cladopora*, *Placocoenites*, *Egosiella*, *Lecomptia*, *Alveolites*, *Coenites*, *Caliapora*, *Grabaulites*, *Armalites*, *Syringopora*, *Roemeripora* (also named as *Loyolophyllum breviseptatum* Bulv.), and *Roemerolites*. Many of the favositid species are unknown earlier. Khalfin (1961) considered it possible that the lower part of the Salairkin beds may represent the upper Emsian.

The Shandin beds of the South-west Kuz basin and North Salair standard sections are generally accepted as Eifelian, and most Russian authors consider them equivalent to part of the Upper Couvinian (Co_2). The Rugosa of the standard Salair sections have been described by Peetz (1901), Chernyshev (1930), Bulvanker (1958, 1963), Ivaniya (1957*a*, 1958*b*, 1960, 1961), Zheltonogova and Ivaniya (1961), and those of neighbouring regions by Spasskiy (1960*c*, *d*), Bulvanker *in* Rzhonsnitskaya *et al.* (1952), Bulvanker *in* Rzhonsnitskaya and Meleschenko 1955). They comprise species of *Barrandeophyllum*, *Thamnophyllum*, *Eridophyllum* [?] *asiaticum* Ivan., *Dendrostella*, *Loyolophyllum*, *Sinospongophyllum major* (Bulv.), *Acanthophyllum*, *Xystriphyllum spp.* [as *Stenophyllum*], fasciculate *Fasciphyllum halliaforme* Soshk., *Taimyrophyllum carinatum* Bulv. [?= *Aphroidophyllum* Lenz, 1961], *Calceola*, *Plasmophyllum* (*Plasmophyllum*) and *P.* (*Mesophyllum*). Lists are given by Spasskiy (1964). See Ivaniya (1965).

The Tabulata of the standard South-west Kuz Basin margin and Salair sections of the Shandin beds have been described by Chernyshev (1951), Dubatolov (1959, 1963, 1964), Chudinova (1959, 1964) and Dubatolov and Mironova (1961*a*, *b*, *c*) and comprise *Favosites goldfussi* d'Orb., *Pachyfavosites polymorphus* (Goldfuss), and species of *Squameofavosites*, *Enmonsia*, *Fomitchevia*, *Pleurodictyum*, *Striatopora*, *Thamnopora*, *Cladopora*, *Alveolites*, *Crassialveolites*, *Caliapora*, *Placocoenites*, *Egosiella*, *Tyrganolites*, *Armalites*, *Natalophyllum*, *Syringopora*, *Heliolites*, *Pachycanalicula*, *Chaetetes*, and *Cyclochaetetes*.

In addition, Kraevskaya (1955*b*) described from the undivided Eifelian (i.e. Salairkin plus Shandin beds), *Pseudospongophyllum massivum* Kraevskaya [? = *Xystriphyllum*], and '*Pseudochonophyllum*'.

Eifelian Tabulata of neighbouring regions have been described from the Mountainous, Southern, and Rudny Altai by Dubatolov and Mironova (1961*a*, *b*, *c*), Dubatolov (1952, 1953, 1955, 1962), and Chudinova (1955, 1959) and from Mongolia and Tuva by Chernyshev (1937*b*). Chudinova (1965) has discussed their palaeoecology. *Tyrganolites* and *Thecostegites* are included in the descriptions from the Losishin beds of the Rudny Altai and *Adetopora* is found in the Tashtyp beds of the Minussinsk trough. Eifelian Rugosa of neighbouring regions have been described from the Mountainous, Southern, Rudny, and Mongolian Altai by Spasskiy (1960*c*, *d*, 1965), Bulvanker *et al.* (1960), Besprozvannykh (1964), Bulvanker *in* Rzhonsnitskaya *et al.* (1952), and Bulvanker *in* Rzhonsnitskaya and Meleshchenko (1955). The faunas are in general similar to those of the Shandin or Mamontov beds or both, but *Minusiella* occurs in the Tashtyp Formation of the Minussinsk trough (considered equivalent to the Shandin beds); *Sinospongophyllum* (as *Tabulophyllum rotundum*) and *Taimyrophyllum* occur in the Losishin beds, *Ridderia* in the Kryukov and Sokolin beds, *Australophyllum* (as *Spongophyllum kurgaense*) in the Rakitin beds, all three formations being regarded as Lower Eifelian. *Stringophyllum* is recorded by Besprozvannykh (1964) from the Eifelian Ust'-Kamen beds. *Rhizophyllum mongolicum* Spasskiy with '*Heliophyllum*' *antiquum* (Soshk.) occurs in the Mountainous Altai in beds considered equivalent in age to the Shandin

beds and *Zmeinogorskia* makes an early appearance at the same horizon but not in the same locality (Spasskiy, 1960*c*).

The Mamontov beds of the standard South-west Kuz–North Salair sections have been regarded as late Eifelian by Dubatolov (1959) and Rzhonsnitskaya (1962) but as Givetian by Chudinova (1964). Rzhonsnitskaya lists the upper Eifelian *Pinacites jugleri* as of the Mamontov fauna but its locality is unknown to me; in the overlying Akarchatkinsk horizon she lists *Maeneceras* regarded as Givetian. Spasskiy (1962) has discussed the boundary between the Eifelian and Givetian stages in the light of the rugosan faunas.

The Rugosa of the Mamontov beds described by Ivaniya (1957, 1958), Zheltonogova and Ivaniya (1961), and Bulvanker (1958) are *Dendrostella*, *Fasciphyllum* [?] *kuznetskiense* Ivaniya, *Grypophyllum gracile* (Wdkd.), *Xystriphyllum spp.*, *Stringophyllum* (*Sociophyllum*) *sp.*, *Plasmophyllum* (*Plasmophyllum*). See also Ivaniya (1965).

The Tabulata of the Mamontov beds are *Favosites*, *Squameofavosites*, *Pachyfavosites*, *Thamnopora*, *Cladopora*, *Alveolites*, *Alveolitella*, *Crassialveolites*, *Placocoenites*, *Tyrganolites*, *Heliolites*, *Thecostegites*, and *Chaetetes* (Chernyshev 1951; Dubatolov 1959, 1963; Dubatolov and Mironova 1961*a*; and Chudinova 1959, 1964). Dubatolov considered that *Squameofavosites*, not known elsewhere above Eifelian equivalents, indicates that the Mamontov beds are Eifelian.

Taimyr

From the Middle Devonian of the Taimyr Spasskiy (1964) listed **Campophyllum soetenicum* Schlüter, **Favistella quadriseptata* Soshk., *Acanthophyllum*, *Neophyma striata* (Soshk.), *Xystriphyllum* [as *Stenophyllum*], **Fasciphyllum* cf. *orientale* (Soshk.), **Diplochone*, *Plasmophyllum* [as *Pseudozonophyllum*], and **Plasmophyllum* (*Mesophyllum*) [as *Digonophyllum*]. Those marked * are considered late Eifelian. Dubatolov and Smirnova (1964) listed *Favosites regularissimus* Yanet, *Pachyfavosites*, *Squameofavosites*, *Pleurodictyum*?, *Alveolites*, *Crassialveolites*, and *Syringopora*. Smirnova (1965*b*) described new species.

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Bulvanker (1965) figured from strata in the Ormulev regions referred to the Eifelian, '*Campophyllum*' *soetenicum* Schlüter, *Anlacophyllum* [?] *Minussiella solida* Bulv. [= *Hexagonaria quadrigemina* group], *Grypophyllum*, *Plasmophyllum versiforme* (Markov), and *P. latum* (Soshk.); Spasskiy (1964) added *Taimyrophyllum* and *Pseudamplexus altaicus* to the list.

The Eifelian Tabulata of the Tas-Khayakhtakh, Sette-Daban, and Ormulev Mt. regions (Dubatolov 1964) form a unit, though different families predominate in the Ormulev Mts. The genera are: *Favosites*, *Pachyfavosites*, *Squameofavosites*, *Thamnopora*, *Cladopora*, *Alveolites*, *Crassialveolites*, *Alveolitella*, *Caliapora*, *Coenites*, *Placocoenites*, *Heliolites*, and *Syringopora*.

Faunal Analysis and Palaeozoogeography

The early Couvinian fauna (of the Salairkin beds and their equivalents) is less sharply distinguished from that of the late Lower Devonian than the latter was from the Tiverian; its most important rugosan genera are *Barrandeophyllum*, *Pseudamplexus*, *Chlamydophyllum*, *Loyolophyllum*, *Favistella*, *Acanthophyllum*, *Neomphyma*, *Fasciphyllum*,

Xystriphyllum, and *Spongophyllum*, all these being known in the late Lower Devonian. But rare *Neocolumnaria*, *Keriophylloides*, *Trapezophyllum*, '*Charactophyllum*' *antiquum*, *Stringophyllum*, and *Calceola* appear. The tabulatan fauna is characterized by the rapid development and dominance of thick-walled *Thamnopora* and *Cladopora* which begin to displace the favositids, by the wide distribution of thick-walled favositids (*Pachyfavosites*, *Oculipora*, *Gephuropora*) that were still sparse earlier (Yanet 1965), by the reduction in importance of *Squameofavosites* and *Favosites*, by the wider distribution of thick-walled alveolitids, and by the occurrence in many regions of *Favosites regularissimus*.

Zoogeographical provinces of the early Couvinian are the same as those of the later Lower Devonian, but the Uralo–Tien Shan province shows great uniformity and the Altai–Sayan province is rather distinct, differing in the large number of *Xystriphyllum spp.* and the absence of *Pseudamplexus*.

The late Couvinian faunas (Shandin and Mamontov) began to luxuriate with wide transgressions of the sea, and in Asia both Rugosa and Tabulata reached their Devonian acme with a remarkable number of genera, species, and individuals. The most characteristic rugosan genera are *Ridderia*, *Oligophyllum*, '*Campophyllum*' *soetenicum*, *Heliophyllum* including '*H*'. *antiquum* (Soshkina), *Cyathophyllum* (*Peripaedium*), *Thamnophyllum*, *Macgeea*, *Neocolumnaria*, *Favistella*, '*Grypophyllum*', *Fasciphyllum*, *Xystriphyllum*, '*Tabulophyllum*', *Plasmophyllum* (*Plasmophyllum*) [as *Pseudomicroplasma*, *Lythophyllum*, *Nardophyllum*, *Zonophyllum*, *Pseudozonophyllum*], and *Plasmophyllum* (*Mesophyllum*) [as *Arcophyllum*, *Digonophyllum*], and *Calceola*.

Of the Tabulata, thamnoporids, alveolitids, and coenitids showed remarkable development; *Thamnopora* and *Cladopora* dominate and with them may occur *Striatopora* and *Fomitchevia*; strong development of wall thickening, of septal elements, and of mural pores characterize the first two. Alveolitids continued to develop thickening of their skeletal elements. *Caliapora* and *Coenites* reached their acme and the appearance of *Placocoenites*, *Tyrganolites*, and *Natalophyllum* is typical for this time. The favositids have waned, *Pachyfavosites* is less numerous, *Squameofavosites*, *Gephuropora*, and *Plicatomurus* have become extinct before the Givetian.

The earlier zoogeographic provinces became less distinct; by the late Couvinian the Uralo–Tien Shan and the Altai–Sayan provinces had become one, to which also the Caucasus and Western Europe belonged, or at least were in communication. The Mongolo–Okhotsk and Indigiro–Kolyma provinces and the Taimyr region also showed immense similarity to the Altai–Sayan region of this common province, with easier diffusion of species. Nevertheless, there were still some provincial differences, such as the occurrence of *Minussiella* in the Minussinsk–Tuva region.

Within the limits of the U.S.S.R. the Givetian faunas are found in smaller areas than the late Eifelian fauna, and are less rich in genera and species.

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